ANNUAL ADDRESS BY THE PRESIDENT,

B. B. Woodward, F.L.S., F.G.S., etc.

(*Delivered* 12*th February*, 1909.)

DARWINISM AND MALACOLOGY.

Members of the Malacological Society,—

Among the several celebrations held of late years in honour of the world's great men, there are certain that more particularly interest us as Naturalists, for while concentrating our attention on one branch of Nature, we do not, if we be true to ourselves, neglect its wider aspects.

The bicentenary of the birth of Linnæus, and that of the birth of Buffon, both fell in 1907. The jubilee of the announcement by Darwin & Wallace of their independent discovery of the Origin of Species by means of Natural Selection was held in July of last year. To-night we celebrate the centenary of the birth of the distinguished philosopher-naturalist, Darwin himself.

To Linnæus (1707–78), "the great lawgiver of systematic zoology," as Huxley terms him (*32*, p. 104), we owe the introduction of method into the study of the three Kingdoms of Nature. He enunciated the true principles for defining genera and species, and this, with his adoption of the simple binomial method of nomenclature, resulted in an orderly and systematic arrangement that enabled the ever-increasing number of plants and animals to be sorted and provisionally placed till their true affinities were ascertained.

His necessarily arbitrary classifications have given way to more natural arrangements in all the three Kingdoms, but the underlying method has remained and enabled continuous progress to be made down to the present time.

Linnæus is commonly regarded as having considered species to be fixed entities in contradistinction to Classes and Orders, which were invented for the convenience of the classifier, and this undoubtedly was his earlier position in regard to the subject. Thus in his "Fundamenta Botanica" (*48*, 1736, p. 19, § 162) he wrote "Naturæ opus semper est Species et Genus," to which in his "Philosophia Botanica" (*49*, 1751, p. 101, § 162) he added "Species constantissimæ sunt, cum earum generatio est vera continuatio." Later in life, however, he obviously had his doubts on the subject, being confronted with the difficulty of satisfactorily accounting for hybrids in plants, for in his thesis "Fundamentum Fructificationis" in 1762 (*50*, p. 16, § 10) the following remarkable passage occurs:—"Suspicio est quam diu fovi, neque jam pro veritate indubia venditare audeo, sed per modum hypotheseos propono: quod scilicet omnes species ejusdem generis ab initio unam constituerint speciem, sed postea per generationes hybridas propagatæ sint, adeo ut omnes congeneres ex una matre progenitæ sint, harum vero ex diverso patre diversæ species factæ." [1]

---

[1] For more detailed remarks on Linnæus and his opinions consult Geoffroy Saint Hilaire (*25*, pp. 373–83) and Osborn (*52*, pp. 128–30).

Linné's celebrated contemporary, Buffon (1707–88), to whom the world owes a great debt for being the first to really popularize Natural History by his monumental work, was, according to Geoffroy Saint-Hilaire (*25*, pp. 383–96), the first to preach the variability of species. At the same time, as the last-named writer shows, he has been quoted by both parties in the old struggle over the question of the fixity or non-fixity of species. In his earlier volumes on Animals he constantly reiterates the statement that they are fixed, but later he admits varieties, which he attributes to degeneration. (Cf. Osborn, *52*, pp. 130–9; Kellogg, *44*, p. 216.)

The true key to Buffon is, however, that indicated by Clodd (*15*, p. 101). Students of Buffon have neglected to take into account his environment. In his first volumes, and notably in his "Théorie de la Terre," he gave expression to views which were not acceptable to the theologians of the day, and these expressions of opinion the Sorbonne, or Faculty of Theology in Paris, compelled him to retract in 1751. Their list of his heresies, with his recantation of them, were published in the forefront of the first volume on Animals (*14*, tom. iv, 1753). In consequence of this submission, Buffon dared not proclaim what he obviously felt to be the truth in the matter, and so, while ostensibly supporting the fixity of species, he by repeatedly drawing attention, almost *ad nauseam*, to the great similarity between related forms, endeavours to lead his readers to the opposite conclusion. No one who carefully reads his chapters on the ass (*14*, tom. iv, p. 377, where *à propos* of its kinship to the horse he passes the whole question in review), on the pig (*14*, tom. v, 1755, p. 99), the dog (*14*, tom. v, p. 194), or the rat (*14*, tom. vii, 1758, p. 278) can fail to see that his remarks are conceived in a spirit of irony. Perhaps the following quotation from the chapter on the goat (*14*, tom. v, p. 59) will give the best illustration of this:—"Quoique les espèces dans les Animaux soient toutes séparées par un intervalle que la Nature ne peut franchir, quelques-unes semblent se rapprocher par un si grand nombre de rapports, qu'il ne reste, pour ainsi dire, entre elles que l'espace nécessaire pour tirer la ligne de séparation."

Geoffroy Saint-Hilaire, unfortunately, only quotes the first part of the sentence, omitting of course the "quoique," thus spoiling the effect of the whole, and he has been followed blindly by all subsequent commentators.

Lamarck (1744–1829), to whom tardy statuary honours are shortly to be paid, at first followed in his teachings on the lines of his master, Buffon, and this continued up to and including the time of his "Recherches sur les causes des principaux faits physiques" (*45*), which was written in 1776 and presented to the Academy in 1780, but not published till 1794. When, however, in 1802, his "Recherches sur l'organisation des corps vivants" (*46*) appeared, his opinions were seen to have undergone an apparent complete change, which culminated in his "Philosophie Zoologique" of 1809 (*47*).

In response to Huxley's comment that "it would be interesting to know what brought about the change of opinion" thus manifested (*33*, p. 748*b*, note), Osborn suggests that it "was probably due to the change of his studies from Botany to Zoology" (*52*, p. 155). A possibly more potent factor, however, appears to have been overlooked; it was once more a question of environment. The Revolution had taken place in those intervening years; the power of the priesthood was broken; and Lamarck was free to boldly advocate, as he did, the transmutation of species.

This transmutation he explained primarily on the theory of changing needs (environment we might say) leading either to the greater use of parts or organs not previously brought so much into play and thus to their development, or, on the other hand, to their disuse and consequent atrophy; in either case the resultant effect reacted on the organism, which became in course of time and generations so modified as to eventuate in a new species. At the same time he advocated the progressive development of Animals and Plants in geological time, and so was the father of Evolution as we understand it.[1]

His theories met with no hearty response at the time, chiefly because the scientific world of the day was not sufficiently advanced to receive the new teaching, which met with Cuvier's strong opposition; but also because the final and convincing argument was lacking and only supplied subsequently in the theory of "Natural Selection" promulgated by Darwin & Wallace (*21*).[2]

We are still, perhaps, too close to the time of Darwin to fully appreciate the magnitude of his work. 'Darwinism,' as it came to be termed, is even now interpreted by the proverbial 'Man in the Street' as explaining man's descent from a monkey, or as I once heard it expressed in front of Darwin's statue in the Natural History Museum, "He discovered the Missing Link, don't you know."

Probably to Darwin's theory more than to any other of the great discoveries in Science has the old aphorism been applicable that first people said "It is not true," then that "It is contrary to Religion," and finally that "Everybody knew it before." Certainly of late years the final stage has been predominant, and many would-be belittlers have arisen and pointed to the lack of originality in the various items of his work.

That such was the case was fully acknowledged by Darwin himself, and he notes that even the Theory of Natural Selection had been anticipated, and the fact lost sight of (*20*, pp. xv and xvi). Thus Dr. W. C. Wells (*61*) in 1813, and Patrick Matthew (*51*, Appendix, pp. 384–7) in 1831, very exactly postulated the view of the Origin of Species propounded by Darwin & Wallace in 1858.

What Darwin did in his "Origin" was to give practical shape to the theory of Evolution by supplying the key to the fitting

---

[1] For more detailed information on Lamarck and his opinions reference should be had to Geoffroy Saint-Hilaire (*25*, tom. ii, pp. 404–11), Kellogg (*44*, p. 263), Osborn (*52*, pp. 156–81), Packard (*54*), and Clodd (*15*, pp. 105–7).

[2] Dr. Jackson, the General Secretary of the Linnean Society, informs me that the historic meeting on 1st July, 1858, was held in the Society's rooms in old Burlington House, now used by the Royal Academy of Arts, the Linnean Society having removed thither from Banks' House in Soho Square in 1857.

together of the puzzle of Life. "He discovered the Missing Link" in a sense other than that cited. "The Origin," wrote Huxley (*22*, vol. ii, p. 197), "provided us with the working hypothesis we sought." The highest tribute to the successful way in which Darwin elaborated and drove home the Theory is that paid by its co-originator, the veteran Alfred Wallace, who, while he realized the value and scope of the Theory, modestly says (*60*, *fide 15*, p. 131), "I have felt all my life, and I still feel, the most sincere satisfaction that Mr. Darwin had been at work long before me, and that it was not left for me to attempt to write the *Origin of Species*. I have long since measured my own strength, and know full well that it would be quite unequal to that task."

Darwin naturally relied mainly on "Natural Selection" to explain the "Origin of Species," and subsequent observers have not been slow to perceive, or backward to demonstrate, that other agencies are also concerned in the production of species, notably the action of 'environment.' What many cavillers have overlooked, however, is that Darwin himself, at the close of the Introduction to the first edition of the "Origin," says, "I am convinced that Natural Selection has been the main but not the exclusive means of modification" (*19*, p. 6), while in the sixth edition (*20*, p. 421) he concludes that species have been modified "chiefly through the natural selection of numerous, successive, slight, favourable variations; aided in an important manner by the inherited effects of the use and disuse of parts; and in an unimportant manner, that is in relation to adaptive structures, whether past or present, by the direct action of external conditions, and by variations which seem to us in our ignorance to arise spontaneously. It appears that I formerly underrated the frequency and value of these latter forms of variation, as leading to permanent modifications of structure independently of natural selection." He returns to the point in a letter to Moritz Wagner in 1876, when he writes (*22*, vol. iii, p. 159), "In my opinion the greatest error which I have committed has been not allowing sufficient weight to the direct action of the environment, i.e. food, climate, etc., independently of natural selection . . . When I wrote the 'Origin,' and for some years afterwards, I could find little good evidence of the direct action of the environment; now there is a large body of evidence."

The present, however, is neither the time nor the place to enter into a lengthy disquisition on Darwin and his work; this has already been done by those competent for the task, while an excellent discussion of Darwinism as it appears to-day has lately been published by Kellogg (*44*).

The following brief general statement appears to me to best epitomize our present knowledge on the subject, and may be permitted on account of what follows.

Every organism possesses an inherent capacity to vary in a greater or less degree in certain directions more or less peculiar to itself.

The influences of environment, using that word in its widest possible sense to include all influences exterior to the organism itself, and possibly to a lesser degree other agencies, by their action on the organism call forth such variation.

Natural Selection then comes into play, and working on the varieties which the environmental conditions have provoked and continue to stimulate, determines, through the survival of the fittest, which of these varieties shall develop into new species.

The process is a consistent whole, and it is waste of time and logic to argue whether the actual origin of the species is to be counted from the time of intervention of natural selection, or reckoned from the point when incipient variation first showed itself. All organisms have undergone and are still undergoing this process of evolution, of which we know not the beginning and cannot forecast the end.

Of all the divisions of the Animal Kingdom the Mollusca probably furnish the best means of tracing out these workings of evolution, for unlike the higher organisms, whose parts only teach the condition of the individual at the moment, the shell of the mollusc properly dissected will yield evidence of its whole life-history. This being true of fossil equally with recent forms, they offer a fine field for investigation. So, too, in a lesser degree, do the Brachiopods and Corals. It may not, therefore, be out of place on the present occasion to summarize what has so far been done in this branch of research, and to indicate what further opportunities for investigation are open.

Hyatt was one of the first to seize on the evolutionary idea and apply it to his particular study, the fossil Cephalopoda. He demonstrated that each Ammonite (and less conspicuously each Nautiloid), when broken up and examined, could be shown to pass through a series of stages changing its form with growth ('ontogenesis'). So great sometimes is the difference between the earlier and later stages that it has not uncommonly happened for two stages of growth in the same Ammonite to have received distinct specific names. For these stages he proposed terms (*39*) which, as subsequently modified in accordance with suggestions made by Mr. S. S. Buckman & Dr. Bather (*13*), have obtained wide currency inasmuch as they are applicable to all forms of animal life (*41*, *42*).

For the sake of those to whom these terms may not yet be familiar, it is permissible to recapitulate them here; they are—

1. Embryonic.	
2. Nepionic . .	Larval, or young.
3. Neanic . .	Immature, or adolescent.
4. Ephebic . .	Mature, or adult.
5. Gerontic . .	Senile, or old.

When these terms are applied to the race instead of the individual the root 'phylo' is prefixed.

Hyatt's next interesting point ('phylogenesis') was that the earlier stages in each individual resembled the adult stages of forms which immediately preceded them in geological time, and of which they were the modified descendants (*34*). Thus in some Ammonites the young shell is smooth, and the margins of the simple septa show but slightly sinuous sutures where they join the shell-wall—in effect they bear a close resemblance to the ancestral Goniatites. With growth the septa and their sutures show successively greater and greater complexity till the well-known foliaceons appearance is presented. The exterior of the shell will also show gradations in its sculpture: the smooth surface of the young Ammonite will develop ribs which, as growth proceeds, become more and more complex, while to the ribs spines may be added. In other forms again the sculpturing of the adolescent, or of the adult shell, gradually disappears with age, the test reverting to a smooth condition.

The individual, therefore, presents in itself a history of its descent, and so to a certain extent of its race. To a certain extent, because Hyatt further found and was the first to point out that there was a tendency, not merely sometimes, as Darwin supposed (*20*, p. 10), but constantly, for the higher forms to reproduce the characters of their predecessors at earlier and earlier stages in their development. "The young of higher species are thus constantly accelerating their development and reducing to a more and more embryonic condition, or passing entirely over, the stages of growth corresponding to the adult periods of preceding or lower species" (*34*, p. 203).

This he denominated the 'Law of Acceleration,' or 'Tachygenesis' (*34*, *40–2*). These phenomena of Ontogenesis, Phylogenesis, and Tachygenesis were also independently discovered by Würtenberger (*62*) and Buckman (*8*, *12*).

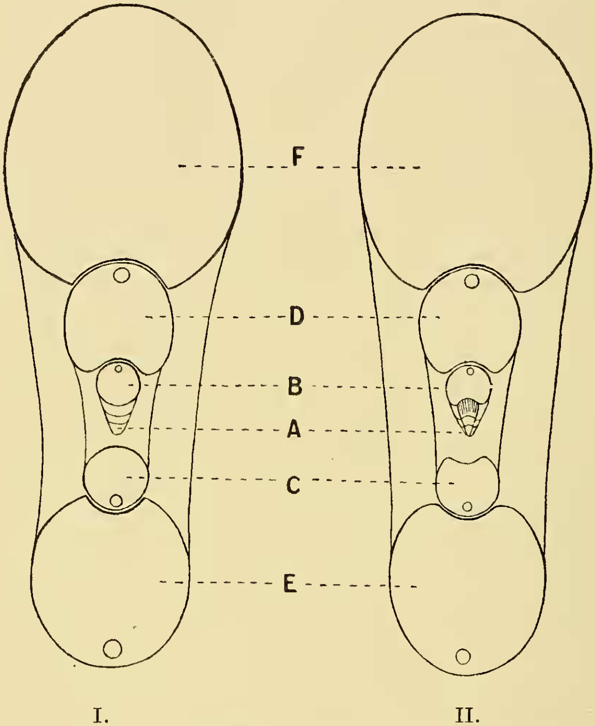
How these principles apply in the phylogeny of the Ammonites will best be shown by the following quotation from a paper by Professor J. F. Blake (*5*, pp. 280–1):—"If we want to know the nearest ancestor of a form A, we must find a form B which reproduces in the adult the early whorls of A; in the same way C, the immediate ancestor of B, must reproduce its [B's] early whorls; and so the series grows. It may, however, often happen, on account of the acceleration, or even abbreviation by curtailment, of development, that the early whorls of the latest, A, do not show us the stages so far back in the history, even on a diminished scale, as the early, or even the later, whorls of C; and so it might be proved, step by step, that a form which, neither in its adult stages nor in any earlier stage agreed with a second, might yet be of the same lineage. In this way a well-proved lineage may pass from so-called species to species, from so-called genus to genus, and from so-called family to family."

Moreover, this process of development takes place not merely in a direct line, but along lines branching, as it were, from some original primitive form.

The genetic relationships among the Ammonoidea have been the subject of many memoirs. The principal writers, beside Hyatt (*34–42*), have been S. S. Buckman (*8–11*), Haug (*30*), Karpinsky (*43a*), Waagen (*59*), Würtenberger (*62–3*), and to their writings the student must turn.

One other contribution to the study of evolution as exhibited in the Cephalopoda claims attention, viz. Hyatt's contention that the group affords proof of the inheritance of an acquired characteristic.

The evidence adduced, in a memoir (*42*) that all should read, may be summarized as follows:—In the Nautilus shell the dorsal or inner side of each whorl is channelled and into this groove ('contact furrow') the preceding whorl fits. Now in the early nautiloids the young shells, which are not closely coiled, show no sign whatever of such furrow, but with the growth of the shell, and the increased tendency to closer coiling, this groove develops as the succeeding



Diagrammatic Sections of Nautiloid Shells.

I. Of an early type, in which the initial whorls (A, B, C), not being in contact, show a sectional outline devoid of indentation, while the later ones (D, E, F) show a 'contact furrow.'

II. Of a late type, in which the initial whorls (A, B, C), still not in contact, exhibit an 'impressed zone,' the precursor of the 'contact furrow' in the later ones (D, E, F).

whorls come in contact, and it not only becomes more and more pronounced in the different forms which follow on in time, but tends by the law of acceleration to develop earlier and earlier in the life-history of the individual, till it is shown, as in the modern Nautilus, as an 'impressed zone' in the very earliest stages, before a single complete whorl has been formed, when its existence serves no purpose, and it simply foreshadows a need to come. Hyatt regards the development of this contact furrow and its beginning, the impressed zone, as an 'acquired characteristic,' it being one that originally had no existence in the phylogeny of the race, but was developed later. Whether the teachers of recent morphology will accept this definition is another matter, for unlike palæontologists they expect more immediate results.

While so much has been done in unravelling the evolution of the Tetrabranchiate Cephalopoda, more still awaits solution, especially among the earlier forms, and the Dibranchia are practically untouched.[1]

Following in the footsteps of Hyatt, under whom he in part studied, R. T. Jackson began similar researches among the Pelecypoda, and dealt with the Aviculidæ (i.e. Pteriidæ) and their allies (*43*).

His work, unhappily, does not carry the same conviction with it as Hyatt's. For this the subject is to blame. The prodissoconchs of Pelecypods seem to afford fewer characteristic features than the protoconchs of Cephalopods, while the later stages exhibit no such marked intrinsic features as do the septa of Ammonoids and Nautiloids. Moreover, the author's genealogical table shows that his conclusions, when dealing with genera having modern representatives, do not coincide with the teachings of investigations founded on the animals and their embryology.

Another attempt to deal with the Pelecypoda from the evolutionary point of view was unfortunately brought to naught, for the intervention of death cut short the projected work of Félix Bernard (*3*), which gave promise of ably carrying through the task of tracing out the ontogeny and morphology of the Pelecypod shell so far as the Tertiary and Recent forms were concerned. As was to be expected from his previous investigations (*2*), the development of the hinge took a prominent place in these researches. The work is a fragment, but we are fortunate in possessing even that from so able a pen.

With the exception of these two writers, Jackson and Bernard, no one seems to have taken up the study of the Pelecypods from the detailed evolutionary point of view, and there is therefore a wide and important field of research awaiting due investigation.

What opportunities for evolutionary research the Gastropoda offer has of late been shown by the series of valuable papers by A. W. Grabau (*26–9*), that deserve the careful attention of all Malacologists.[2] His examples are chiefly drawn from families high up in the phylogeny of the race (*Fusus*, *Murex*, *Sycotypus*, *Fulgur*), and so do not afford scope for any really wide generalizations; nevertheless, they teach much, as the following résumé of his conclusions will show.

For purposes of study the Gastropod shell presents an advantage over

---

[1] In the foregoing observations on the Cephalopoda I have had the advantage of Mr. G. C. Crick's kind assistance and advice, and I gladly take this opportunity of returning to him my sincerest thanks.

[2] The classical work by Neumayr (*51a*) on the evolution of the species of *Vivipara* in the Neogene beds of Slavonia, with Hilgendorf's (*30a–c*) and Hyatt's (*38a, b*) papers on the phylogeny of the forms of *Planorbis multiformis* from the Miocene of Steinheim, being limited in their scope, need not detain us, valuable as they are.

that of the Cephalopod in that the greater part of the whorls are exposed, whereas in the latter the older are mostly concealed by the newer whorls.

The form of the Gastropod shell is multiple, but the types are few. Primitive types always begin with a protoconch having rounded whorls, free from all ornamentation. When the whorls remain rounded throughout the life of the species no regular ornamentation is as a rule produced. Generally, however, a change from the primitive rounded outline to an angular one takes place by the formation of a peripheral keel. The subsequent shape of the shell will then depend upon the position of this keel, whether high up or low down on the whorl, and the extent to which the succeeding whorls overlap each other. Occasionally more than one carina is developed. Keeled shells usually exhibit several forms of surface ornamentation, such as ribs, spiral liræ, nodules, and spines. Of these the ribs are usually the first to appear, but many instances will readily occur to conchologists in which the spiral lines have precedence and are even found on the protoconch itself. The cause of these adornments is uncertain, but Grabau, bettering Dall's suggestion for the columellar plaits of *Voluta* (*17*, pp. 58–61 ; *18*), attributes the formation of the spiral liræ to the wrinkling of the mantle as the animal withdraws into its shell; he apparently forgets that the new shell is formed when the animal is extended. Moreover, plications formed simply by the folding of a flexible surface would be apt, like the lines on the palms of our hands, to show considerable individual variation, a condition not exhibited in shells where the regularity of the spiral liræ is usually constant for the species.

The evolution of the spines and their development in the life of a single individual, as in *Murex brevifrons* (*26*, pp. 934–5) is very happily traced by Grabau, but it is difficult to follow him when, especially in the Melanias, he claims for them a regular phylogenetic sequence (*28*, p. 639). One wonders what he would make of the ornamentation displayed by *Tanalia aculeata* (Gmelin), of which H. F. Blanford collected specimens from the same spot in a given stream exhibiting very considerable range of graduated variation, from coarsely granulated to smooth forms (*6*). Beecher in his admirable memoir (*1*, p. 353) argues that spines, or, rather, a spinose condition, occurs just after the culmination of a group, and is to be taken as the visible evidence of the beginning of the decline of the vitality of the group. Packard (*53*, pp. 505–6) inclines to attribute the development of spines, in some cases at all events, to a response to a change of environment, and says: "It is not improbable that the appearance of such highly or grotesquely ornamented forms as certain later Brachiopods, Trilobites, and Ammonites was the result of a change in their environment." In the case of our common *Cardium echinatum*, Linn., it may be remarked, the size and number of the spines vary with the nature of the sea-bottom, being fewer and smaller in proportion as the silt in which they bury is firmer.

Many Gastropods, after passing through the juvenile stage of a plain protoconch and developing the characteristic ornamentation of their tribe or species in the adult (aggregational development), will in their old age lose their ornamentation by stages that reverse the order in which it developed and finally revert to a smooth-whorled condition (degradational development), just as Hyatt found to be the case in Ammonites.

All these successive stages follow the sequence outlined above in regular order, and to this Grabau applies the term "Orthogenetic Variation." To quote his own words: "Orthogenetic Variation may be defined as progressive variation along definite or determinate lines, whether such variation is along the line of increasing or decreasing complexity, i.e. aggregational or degradational" (*28*, p. 607).

The law of tachygenesis is well shown in Gastropoda when a series of forms are traced through successive geological epochs, as Grabau has done for *Fulgur*, *Sycotypus* (*27*), and *Fusus* (*29*).

That the study of orthogenetic development in the different families of Mollusca, and more careful attention to the character of the protoconch,[1] due allowance being made for differences in individuals living under diverse conditions (the Heterostylism of Boettger (7)), may lead to the sorting out of forms, hitherto classed together owing to similarity of form in the adult, is more than probable. It may also lead to the phylogenetic association of groups hitherto considered to be unrelated.[2] It is not, however, possible to follow Grabau when, led away by enthusiasm for his special study, he maintains that similarity of lingual dentition should be subordinate to shell characters (*27*, p. 537). Nor can assent be given when he classes patelloid shells with uncoiled and, according to him, degenerate forms like those of *Vermetus*, *Cyclosurus*, and many another from Lower Cambrian times to the present day (*26*, pp. 938–9; *28*, p. 623). The patelloid shell is not the result of uncoiling, but of a total alteration in growth to suit it to the animal's mode of living. To label *Patella* and other cognate forms phylogerontic is to misapply that much abused and overworked term. One might equally describe *Dentalium* as phylogerontic!

In this matter it would seem as if the disciple had, as disciples are apt to do, gone further than the master, for Hyatt points out (*42*, p. 588): "There is an obvious correlation between coiling of the shell and the habit of crawling. Thus all univalve crawling mollusca have this general tendency. Among Gasteropoda this is well known, and those shells which degenerate and tend to lose the spiral mode of growth and become irregularly straightened out in these older stages of growth, are forms which become attached or lead sedentary lives, i.e. *Vermetus* attached late in life and *Magilus* buried in coral. The most significant case, however, is that of *Fissurella*, which has a coiled

---

[1] "I believe it is not too much to say that the protoconchs of all the species within a given genus should agree as to their essential characteristics, and that no species can be considered congeneric in which the protoconchs show a radical difference" (Grabau, *26*, p. 922).

[2] Grabau puts *Buccinum* and *Fulgur* with *Fasciolaria*, and *Melongena* and *Hemifusus* with *Fusus* (*27*, p. 537), considers *Levifusus* closely related to *Pleurotoma* (*27*, p. 526), and hints that *Pterocera* is polyphyletic (*26*, p. 930, note).

shell in the nepionic stage and becomes similar to *Patella*, a depressed, straight cone in the neanic and ephebic stages, the habitat being like that of *Patella* and the approximate forms of *Haliotis* and others, comparatively sedentary upon littoral rock ledges." Jackson, too (*43*, p. 294), who had the benefit of Hyatt's direct teaching, refers the uncoiled stage of *Vermetus* to the ephebic or adult period, and therefore by no means considers it herontic.

So far, then, as the Gastropoda are concerned, we are but on the threshold of inquiry, and there is need of much further work among other groups and especially the older fossil forms.

The chief object in thus drawing attention to such progress as has been made in the study of molluscan phylogeny and in emphasizing the fact that so much more of very great interest remains to be done, is the hope that some members of this Society may be persuaded to take up this branch of investigation, hitherto comparatively neglected in England. Opportunity, of course, will not come to all, but for willing workers other less comprehensive fields of research connected with the question are equally open. As an example may be instanced the excellent work done quite lately by Mr. E. S. Russell in studying the Limpet.

In his memoir (*55*), after narrating the results of experiments on the well-known homing propensities of this mollusc, that demonstrate large Limpets to be more fixed in their positions than small ones, Mr. Russell turns to the influences of environment on the size and character of the shell. He finds that the shells of those Limpets which live near high-water mark are at every stage of their growth higher spired and a little broader, though narrower in proportion to their height, than low-water shells. Also the proportion of large shells is greater at high-water than at low-water sites. When those inhabiting exposed are contrasted with shells in sheltered spots in a given definite locality, the former are found to be proportionately narrower than the latter. Observation showed that of the two types of shell, the rough and the smooth, the first-named were attached to rough, the others to polished stones, and were simply the result of the growing shell-margin moulding itself to the surface of attachment, so that the two types are the outcome of a single environmental character.

Similar observations are now required with respect to other inter-tidal molluscs.[1] The effect of environment on molluscs is as yet but very imperfectly understood. Beudant's experiments (*4*) on the

---

[1] At a meeting of the Challenger Society held on January 27th of this year, Mr. W. M. Tattersall gave some exceedingly interesting details concerning the breeding habits and development of the British species of *Littorina*. It appears that the eggs of *L. littorea* are deposited in small capsules shaped like a Panama hat, and are not attached, which accounts for their not having been recorded hitherto. The species is exposed only at low spring tides, and the embryo is freed as a trochosphere, later attaining the veliger stage; the embryo of *L. obtusata*, which is exposed at ordinary low water, is freed as a veliger; *L. rudis* and *L. neritoides*, on the other hand, which live at the high-water line, are viviparous. A remarkable instance this of adaptation to suit environmental conditions. (Cf. *Athenæum*, February 13th, 1909, pp. 203–4.)

capacity of freshwater molluscs to survive in salt water, and vice versa, require repetition and extension; so, too, do both Semper's (*56–8*) and Varigny's (*58a*) experimental dwarfing of *Limnæa*.

The influence of different foods on even the commonest of our garden snails, easily as they may be kept under observation, is practically unknown—nay, the ordinary food of many is not fully understood, and Gain (*23*, *24*) seems the only person who has conducted practical experiments on the subject. The habitat and mode of life of many terrestrial mollusca, even the commonest, call for further scrutiny: of this type of œcological investigation the Rev. A. H. Cooke's paper (*16*), lately contributed to our Proceedings, is a good example.

All these things should claim our attention, for, to quote Kellogg (*44*, p. 387): "Our work is to learn. To observe, to experiment, to tabulate, to induce, to deduce. Biology was never a clearer or more inviting field for fascinating, joyful, hopeful work. To question life by new methods, from new angles, on closer terms, under more precise conditions of control; this is the requirement and opportunity of the biologist of to-day. May his generation hear some whisper from the Sphinx!" But, as Huxley so wisely expressed it (*31*, p. 390): "Those who wish to attain to some clear and definite solution of the great problems which Mr. Darwin was the first person to set before us in later times must base themselves upon the facts which are stated in his great work, and, still more, must pursue their inquiries by the methods of which he was so brilliant an exemplar throughout the whole of his life. You must have his sagacity, his untiring search after the knowledge of fact, his readiness always to give up a preconceived opinion to that which was demonstrably true, before you can hope to carry his doctrines to their ultimate issue; and whether the particular form in which he has put them before us may be such as is finally destined to survive or not is more, I venture to think, than anybody is capable at this present of saying. But this one thing is perfectly certain—that it is only by pursuing his methods, by that wonderful single-mindedness, devotion to truth, readiness to sacrifice all things for the advance of definite knowledge, that we can hope to come any nearer than we are at present to the truths which he struggled to attain."

WORKS REFERRED TO.

1. BEECHER (C. E.). "The Origin and Significance of Spines," etc.: Amer. Journ. Sci., ser. IV, vol. vi, 1898, pp. 1–20, 125–36, 249–68, and 329–59.
2. BERNARD (F.). "Première (-Quatrième) Note sur de développement et la morphologie de la Coquille chez les Lamellibranches": Bull. Soc. géol. France, sér. III, tom. xxiii, 1895, pp. 104–54; xxiv, 1896, pp. 54–82, 412–49; xxv, 1897, pp. 559–66.
3. ———— "Recherches ontogéniques et morphologiques sur la Coquille des Lamellibranches": Ann. Sci. Nat. (Zool.), sér. VIII, tom. viii, 1898, pp. 1–208, 12 pls.
4. BEUDANT (F. P.). "Mémoire sur la possibilité de faire vivre des Mollusques fluviatiles dans les eaux salées, et réciproquement," 4to, Paris, 1816.
   ⁎ His results are reproduced by Semper (*infra*, 58, p. 439).
5. BLAKE (J. F.). "The Evolution and Classification of the Cephalopoda," etc.: Proc. Geol. Assoc., vol. xii, 1892, pp. 275–95.

6. Blanford (H. F.). "On the specific identity of the described forms of *Tanalia*": Trans. Linn. Soc. London, vol. xxiii, 1862, pp. 603–10, 1 pl.
7. Boettger (O.). "Ueber Heterostylie bei Schneckenschalen und ihre Erklärung": Nachrbl. Deutsch. Malak. Ges., 1905, pp. 26–35.
8. Buckman (S. S.). "A Monograph of the Inferior Oolite Ammonites of the British Islands" (Pal. Soc. Monog.), 4to, 1887, etc.
9. ——— "The Descent of *Sonninia* and *Hammatoceras*": Quart. Journ. Geol. Soc., vol. xlv, 1889, pp. 651–63, 1 pl.
10. ——— "Morphology of '*Stephanoceras*' *zigzag*": op. cit., vol. xlviii, 1892, pp. 447–52, 2 pls.
10*a*. ——— "On the grouping of some divisions of so-called 'Jurassic' Time": op. cit., vol. liv, 1898, pp. 442–62, 2 tables.
11. ——— "On certain genera and species of Lytoceratidæ": op. cit., vol. lxi, 1905, pp. 142–54, 2 pls.
12. ——— "Some Laws of Inheritance; and their application to Man": Proc. Cotteswold Naturalists' Field Club, vol. x, 1892, pp. 258–322.
13. Buckman (S. S.) & Bather (F. A.). "The Terms of Auxology": Zool. Anzeiger, 1892, pp. 420, 429.
14. Buffon (G. L. L. de), *Count*. "Histoire Naturelle," etc., 44 tom., 4to, Paris, 1749–1804.
15. Clodd (E.). "Pioneers of Evolution from Thales to Huxley," etc., 8vo, London, 1897.
16. Cooke (A. H.). "The Habitat of certain species of *Clausilia* from Dalmatia, Herzegovina, and Bosnia": Proc. Malac. Soc. Lond., vol. viii, 1908, pp. 142–5.
17. Dall (W. H.). "Contributions to the Tertiary Fauna of Florida," etc.: Trans. Wagner Free Inst. Sci., vol. iii, 1890.
18. ——— "The mechanical cause of folds in the aperture of the shell of Gasteropoda": Amer. Naturalist, vol. xxviii, 1894, pp. 909–14.
19. Darwin (C. R.). "The Origin of Species by means of Natural Selection," etc., 8vo, London, 1859.
20. ——— ——— Sixth edition (corrected to 1872), 8vo, London, 1884.
21. Darwin (C. R.) & Wallace (A. R.). "On the tendency of Species to form Varieties; and on the perpetuation of Varieties and Species by means of Natural Selection": Journ. Linn. Soc. Lond. (Zool.), vol. iii, 1858, pp. 45–62.
22. Darwin (F.). "The Life and Letters of Charles Darwin," etc., 3 vols., 8vo, London, 1887.
23. Gain (W. A.). "A few notes on the food and habits of Slugs and Snails": *Naturalist*, 1889, pp. 55–9.
24. ——— "Notes on the Food of some of the British Mollusks": Journ. of Conch., vol. vi, 1891, pp. 349–61.
25. Geoffroy Saint-Hilaire (I.). "Histoire naturelle générale des Règnes organiques," etc., tom. ii, 1856.
26. Grabau (A. W.). "Studies of Gastropoda. I": Amer. Nat., vol. xxxvi, 1902, pp. 917–45.
27. ——— ——— "II. *Fulgur* and *Sycotypus*": op. cit., vol. xxxvii, 1903, pp. 515–39.
28. ——— ——— "III. On Orthogenetic Variation in Gastropoda": op. cit., vol. xli, 1907, pp. 607–46.
29. ——— "Phylogeny of *Fusus* and its allies": Smithson. Miscell. Coll., vol. xliv, 1904, pp. 157, 18 pls.
30. Haug (E.). "Beiträge zu einer Monographie der Ammonitengattung *Harpoceras*": Neues Jahrb. Mineral., 1885, Beil. Bd. iii, pp. 585–722, 1 pl.
30*a*. Hilgendorf (F.). "*Planorbis multiformis* im Steinheimer Süsswasserkalk," etc.: Monatsber. k. Akad. Wissensch. Berlin, 1866, pp. 474–504.
30*b*. ——— "Noch einmal *Planorbis multiformis*": Zeitschr. Deutsch. geol. Gesell., 1877, pp. 50–62.
30*c*. ——— "Neue Forschungen in Steinheim": op. cit., 1877, pp. 448–56.
31. Huxley (L.). "Life and Letters of T. H. Huxley," 2 vols., 8vo, London, 1900.

32. Huxley (Right Hon. T. H.). "Evidence as to Man's place in Nature," 8vo, London, 1863.
33. ——— "Evolution": Encycl. Brit., 9th ed., vol. viii, 1878, pp. 744–73.
*** Republished in "Science and Culture," etc., 8vo, London, 1882.
34. Hyatt (A.). "On the parallelism between the different stages of Life in the Individual and those in the entire group of the molluscous order Tetrabranchiata": Mem. Boston Soc. Nat. Hist., vol. i, 1867, pp. 193–209.
35. ——— "On Reversions among the Ammonites": Proc. Boston Soc. Nat. Hist., vol. xiv, 1871, pp. 22–43; Appendix, op. cit., vol. xvii, 1874, pp. 23–7.
36. ——— "The non-reversionary series of the Liparoceratidæ": op. cit., vol. xv, 1872, pp. 4–21; Appendix, op. cit., vol. xvii, 1874, pp. 29–33.
37. ——— "Genetic relations of the Angulatidæ": op. cit., vol. xvii, 1874, pp. 15–23.
38. ——— "Genetic relations of *Stephanoceras*": op. cit., vol. xviii, 1876, pp. 360–400.
38*a*. ——— "The genesis of the Tertiary Species of *Planorbis* at Steinheim": Anniv. Mem. Boston Soc. Nat. Hist., 1880.
38*b*. ——— "Transformations of *Planorbis* at Steinheim," etc.: Proc. Amer. Assoc., vol. xxix, 1880, pp. 527–50.
39. ——— "Values in classification of the stages of growth and decline, with propositions for a new nomenclature": Proc. Boston Soc. Nat. Hist., vol. xxiii, 1888, pp. 396–407.
40. ——— "Genesis of the Arietidæ": Smiths. Contrib. Knowledge, vol. xxvi, 1889.
41. ——— "Bioplastology and the related branches of Biologic Research": Proc. Boston Soc. Nat. Hist., vol. xxvi, 1893, pp. 59–125.
[An amplification of his "Values" (39). Repeated in his "Phylogeny" (42).]
42. ——— "Phylogeny of an Acquired Characteristic": Proc. Amer. Phil. Soc., vol. xxxii, 1894, pp. 349–647, 14 pls., figs.
43. Jackson (R. T.). "Phylogeny of the Pelecypoda. The Aviculidæ and their Allies": Mem. Boston Soc. Nat. Hist., vol. iv, 1890, pp. 277–400, 8 pls., figs.
43*a*. Karpinsky (A.). "Ueber die Ammoneen der Artinsk-Stufe und einige mit denselben verwandte carbonische Formen," pp. 104, 5 pls.: Mém. Acad. imp. Sci. St. Petersbourg, sér. vii, tom. xxxvii, No. 2, 1889.
44. Kellogg (V. L.). "Darwinism To-day," etc., 8vo, London, etc., 1907.
[This work contains very full references to the bibliography of the subject appended to each chapter.]
45. Lamarck (J. B. P. A. de M. de). "Recherches sur les causes des principaux faits physiques," etc., 2 tom., 8vo, Paris, An. 2 [1794].
[The work was written in 1776 and presented to the Academy in 1780.]
46. ——— "Recherches sur l'organisation des corps vivants et particulièrement sur son Origin," etc., 8vo, Paris [1802].
47. ——— "Philosophie Zoologique, ou exposition des considérations relatives à l'histoire naturelle des Animaux," etc., 2 vols., 8vo, Paris, 1809.
48. Linnæus (C.). "C. Linnæi . . . Fundamenta Botanica," etc., 12mo, Amstelodami, 1736.
49. ——— "C. Linnæi . . . Philosophia Botanica," etc., 8vo, Stockholmiæ, 1751.
50. ——— "Fundamentum fructificationis," etc., 4to, Upsaliæ [1762].
[Also in "Amœnitates," vol. vi, pp. 277–304.]
51. Matthew (P.). "On Naval Timber and Arboriculture," etc., 8vo, London, 1831. Appendix, pp. 384–7.
51*a*. Neumayr (M.) & Paul (C. M.). "Die Congerien- und Paludinenschichten Slavoniens," pp. iv, 106, 10 pls.: Abhandl. k. k. Geol. Reichsanstalt, Wien, Bd. vii, 1875, No. 3.
52. Osborn (H. F.). "From the Greeks to Darwin," 8vo, New York, etc., 1894.
53. Packard (A. S.). "Hints on the Evolution of the Bristles, Spines, and Tubercles of certain Caterpillars," etc.: Proc. Boston Soc. Nat. Hist., vol. xxiv, 1890, pp. 494–560.
54. ——— "Lamarck, the founder of Evolution: his Life and Work," etc., 8vo, New York, etc., 1901.

55. Russell (E. S.). "Environmental Studies on the Limpet": Proc. Zool. Soc. Lond., 1907 (1908), pp. 856–70, figs.
56. Semper (K.). "Ueber das Wachsthum von *Lymnæus stagnalis*": Verhandl. phys. med. Gesell. Würzburg, n.f., Bd. iii, 1872, pp. 271–9.
57. ——— "Ueber die Wachsthums-Bedingungen des *Limnæus stagnalis*": op. cit., n.f., Bd. iv, 1873, pp. 50–79; reprinted in Arbeit. zool.-zootom. Inst. Würzburg, Bd. i, 1874, pp. 137–67.
*** Summarized in the author's later work (58, pp. 161–7).
58. ——— "The natural conditions of existence as they affect Animal Life": 3rd ed. (Internat. Sci. Series), 8vo, London, 1883.
58*a*. Varigny (H. de). "Recherches sur le Nanisme expérimental," etc.: Journ. Anat. and Physiol., vol. xxx, 1894, pp. 147–88.
59. Waagen ( ). "Die Formenreihe des *Ammonites subradiatus*": Geognost. und Palæont. Beiträge, Bd. ii, Heft ii, 1869, pp. 181–256, 8 pls.
60. Wallace (A. R.). "Contributions to the Theory of Natural Selectiou," 1870.
61. Wells (W. C.). "An account of a White Female, part of whose skin resembles that of a Negro."
[This paper was read before the Royal Society in 1813, but was not published till it appeared with his "Two Essays upon the Dew and Single Vision" in 1818.]
62. Würtenberger (L.). "Neuer Beitrag zum geologischen Beweise der Darwin'schen Theorie": Ausland, 1873, pp. 6–10, 25–9.
63. ——— "Studien über die Stammesgeschichte der Ammouiten": Darwinistische Schriften, No. 5, 1880.